Leukaemia in Greece did not rise

EDITOR,—Two papers report that, after the accident at Chernobyl, childhood leukaemia did not increase in Finland[1] and Sweden.[2] Because of the direction of the prevailing winds after the accident several parts of Greece were exposed to substantial fallout radiation at levels comparable to those registered in Scandinavian countries. Neither in Greece as a whole nor in the most heavily irradiated parts of the country was an increase in the incidence of childhood leukaemia found after the accident until the end of 1991. Detailed results have been reported[3] and should form part of the collective evidence that has been substantially advanced through the publication of the two Scandinavian papers.

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Chromosomal abnormalities increased in Latvia

EDITOR,—The *BMJ* of 16 July includes several articles on childhood cancer after the accident at Chernobyl in 1986. The studies from Finland and Sweden conclude that there is no evidence of an increase in childhood leukaemia.[1,2] I wish to draw attention to a special population in Latvia affected by the accident.

Between 1986 and 1989, 6000 factory workers of Latvian and Russian origin were taken to help workers clearing up the site of the Chernobyl accident. The dose of radiation received by these workers can only be estimated since few workers were provided with dosimeters, which were often switched off during work anyway. Latvia has no facilities to measure total body radiation. But in the past four years rising medical and public awareness of potential consequences of exposure to radioactivity has led to a comprehensive follow up study of the workers who helped to clean up the site; this has been conducted in regular clinics in the districts and at the Republican Hospital in Riga. The study has led to an important database being established. There is evidence of abnormalities and increased breakage of the chromosomes on chromosomal analysis as well as impaired function of the immune system in some of the workers.

The main difficulty has been to establish an aetiological connection between changes in general health and exposure to radiation as the doses of radiation received are uncertain and the workers are at risk of multiple occupational diseases in their normal working environment in Latvia. A follow up study of the children of these workers who were born after 1986 began in 1992 and faces difficulties owing to financial and structural problems.

Results very different from those of the Scandinavian studies might emerge if the Latvian populations were analysed as systematically as were the populations in the Scandinavian studies. International help is required to study these populations and to gather more information about the effects of low dose radiation on adults and their offspring. The three doctors in charge of the follow up studies are Professor Maija Eglite, Head, Latvian Occupational Diseases Department, Latvian Medical Academy, 226012 Riga, Latvia; Dr Igors Stepanov, Department of Health, 226331 Riga; and Dr Jelena Ambalova, Director, Paediatric Outpatient Department, Republican Children's Hospital, 226004 Riga, Latvia.

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Authors stand by study that Chernobyl increased trisomy 21 in Berlin

EDITOR,—John Boice and Martha Linet express serious concerns[1] about the validity of the results of our study and their interpretation.[2] We wish to respond to their comments.

Firstly, Boice and Linet say that larger and more representative series in Europe did not detect any effect. The authors of the largest European study, in which no effect was observed, have pointed out several limitations of their analysis, of which sample distortion and information bias are the most serious.[3] In addition, with regard to the hypothesis concerning iodine 131 in our study, most of the participating centres were in regions where the nutritional iodine intake was higher, and thus the uptake of radioactive iodine lower, than that in Germany. This holds especially for the Finnish study.[4] A significant increase in the rate of Down's syndrome was also, however, observed for infants born in 1987 in the Lothian region of Scotland, in Sweden, and in Denmark.

Secondly, the authors say that we did not take bias into account. Since ascertainment of trisomy 21 was virtually 100% during the 10 year period reporting bias can be excluded a priori. With regard to observation bias ("shown by the notably sharper increase in prenatal diagnoses between 1986 and 1987"), it is impossible that an increase in prenatal diagnoses during 1987 should have had any effect on cases detected postnatally in January 1987; the increase in 1986 was one of the lowest. With regard to confounding bias (no adjustment for maternal age), our study was unusual with respect to ascertainment of maternal age: owing to the island-like situation of West Berlin at that time, the age of all pregnant women was known. The average maternal age in 1987 was in the lower range, and any adjustment would have strengthened our observations. Our calculations were conservative.

Thirdly, the authors say that the Berlin study is at odds with the evidence accumulated so far on the possible association between ionising radiation and trisomy 21. We explained in our discussion why "negative" findings in studies of children of Japanese survivors of the atomic bombs do not contradict our conclusions. Even the senior investigators have admitted that their survey will not yield adequate data on the frequencies of autosomal trisomies.[5,6] In a discussion of the effects of low dose radiation on non-disjunction in humans the authors conclude that nine of 13 studies showed a positive and only two a negative effect[7]; we do not see any way of interpreting this as equivocal.

Finally, the authors comment on the male excess in our study. The sex ratio among liveborn infants with trisomy 21 is about 1.35:1. Thus the probability of there being eight or more boys in a series of 10 children exceeds 10%.

We believe that the authors did not provide any valid support for their criticism. Given the nature of our study, a cause and effect relation between the accident at Chernobyl and the cluster of cases of trisomy 21 in Berlin cannot be proved, but it can be taken as a serious hypothesis, which "raises questions about the currently accepted estimates"[7] and may guide further research.

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Not all health problems seen close to Chernobyl can be attributed to radiation

EDITOR,—Considerable concern has been expressed about the adverse consequences on health of the accident at Chernobyl nuclear power station.[1] We have reported findings in people exposed short term to high dose radiation at the power station.[2] Little is known, however, about effects on health among inhabitants of Pripyat, a city 4 km from the plant, who were exposed to lower radiation doses.

In 1991 we first studied a 5 year old boy born two weeks before the accident, who was outdoors most of the day of the accident, when ambient radiation was high. His mother reported vomiting that evening. The next day the child and other inhabitants of Pripyat were evacuated. He became irritable, developed vomiting and seizures, and eventually became comatose. Encephalitis induced by radiation was tentatively diagnosed, and he was

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admitted to hospital for about three months. Supportive care and transfusions were given, but no diagnostic procedures were performed.

Our examination showed a normally developed child of average intelligence. Notable findings included bilateral fascicular visual field defects, bilateral papilloedema, and decreased visual acuity in the left eye owing to astigmatism. While under observation the child had a generalised seizure. An electroencephalogram showed non-specific abnormalities, and a computed tomogram was normal. Carbamazepine was begun, and he had no further seizures. All laboratory studies yielded normal results, and subsequent growth and development were normal.

In 1991 we performed cytogenetic analyses of blood lymphocytes to determine the radiation dose. No chromosomal abnormalities were detected in 500 lymphocytes studied. Calculations that took into account the likely cell turnover since the accident suggested a radiation dose of less than 0·4 Gy. In 1993 we studied dental enamel from a deciduous tooth by electron spin resonance. There was no evidence of exposure to radiation at a detection threshold of 0·3 Gy. These measurements are consistent with Soviet estimates that the population of Prypiat was exposed to radiation of $< 0{\cdot}02$ Gy.[3]

Fetuses and newborn infants are more susceptible than adults to neurological damage induced by radiation.[4] Doses reported to cause these effects, however, generally exceed 2 Gy. Also, children with brain tumours and leukaemia treated with radiation to the central nervous system have an increased frequency of neuropsychological and neurological dysfunction.[5] Doses responsible for these effects generally exceed 15 Gy. On the basis of these data we believe that this child's neurological problem was probably unrelated to the exposure to radiation and a sequel of encephalitis of undetermined aetiology. We caution against ascribing illnesses that develop in people who were exposed to radiation around Chernobyl to the radiation.

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Editorial authors' response

EDITOR,—Areas far from Chernobyl received relatively small amounts of fallout from the reactor accident, and associations with childhood leukaemia have not been found.[1] The absence of a correlation between fallout in Greece and childhood leukaemia is thus not surprising.[2] In our editorial we also emphasised the greater scientific value of conducting analytical (cohort and case-control) studies of more heavily exposed populations, such as workers who cleaned up after the accident, people living near Chernobyl, and children exposed to iodine-131.[1]

We agree with E D Williams and Theodor Abelin and colleagues that an aetiological connection between fallout from Chernobyl and thyroid cancer in children is probable. The studies published thus far, however, have not resolved several important issues. For example, because ecological study designs have been used, no relation between individual doses and risk of cancer has been shown.

Furthermore, a substantial number of the thyroid cancers occurring in children in Belarus and the Ukraine were detected within five years of the accident. In contrast, among Marshall Islanders exposed to fallout from nuclear weapons testing the first thyroid tumour occurred nine years later.[3] A combined analysis of all major studies of childhood irradiation also showed only two thyroid cancers (fewer than expected) within five years of exposure.[4] The short latency also seems at odds with an analytical study conducted 4·5 years after the Chernobyl accident, which showed no difference in thyroid nodules detected by ultrasonography between people living in highly contaminated villages and those living in control settlements.[5] Although the influence of intense screening is difficult to quantify, screening programmes not only find relatively small tumours but also detect indolent tumours of all sizes, even among non-exposed people.[4] Thus an increase in thyroid cancer is to be expected in any screened population. It is hoped that continuing epidemiological research will address these remaining issues and show the causal mechanisms behind the spectacular increase in thyroid cancer among children living in these areas.

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Studies may have had inadequate statistical power

EDITOR,—Studies on possible excess cases of childhood cancer in Finland and Sweden due to radioactive fallout from Chernobyl are based on extended follow up by cancer registries[1,2] and show essentially negative results.[3] This might be due to their limited statistical power to detect the effects of low dose exposures. The radioactive exposure in central and northern European countries should always be compared with the natural exposure there. Contamination in Austria due to fallout from Chernobyl has been similar to that in Scandinavia. For 1986 an annual effective dose equivalent of 0·8 mSv has been reported by the Austrian government. This compares with an effective dose equivalent in the Northern hemisphere of about 4·5 mSv resulting from tests of heavy nuclear weapons in the atmosphere to the end of 1980.[4]

We measured gross β activity in snow samples deposited in Alpine glaciers, which are contaminated to roughly the same extent by fallout from nuclear weapons tests in the atmosphere and by fallout from the Chernobyl accident. On glaciers atmospheric fallout is conserved in layers of snow, whose time of deposition can be determined. The maximal contamination from nuclear weapons tests in the atmosphere occurred in snow layers deposited in 1963, with activity of about 100 Bq/kg snow. For both events the same sampling techniques and the same counting devices were used.[5]

To evaluate possible risks the effective dose equivalent of about 0·8 mSv from fallout from Chernobyl in Austria in 1986 has to be compared with background radiation resulting from natural sources. Outdoor exposure due to different geological patterns of the ground varies between 0·5 and 7 mSv, and the exposure from cosmic rays increases to about 0·65 mSv at an altitude of 2000 m, compared with about 0·3 mSv at sea level. Additionally, exposure to indoor radon must be taken into account. In Britain this contribution is estimated to be about 1 mSv of the average annual exposure of 2·5 mSv.[6] In Austria the effective dose equivalent due to indoor radon should be higher.

Because of this range of possible exposures due to natural sources it is not surprising that epidemiological studies do not find significant evidence for an increased incidence of childhood cancer due to fallout from Chernobyl in middle and northern Europe.

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Authors' reply

EDITOR,—Walter Ambach and Wolfgang Rehwald point out that radiation exposure from the fallout from Chernobyl was relatively small and that other sources of exposure are important. They therefore argue that epidemiological studies, including ours, are unable to detect the effects of fallout from Chernobyl on the incidence of childhood leukaemia.

In Finland the effective dose of radiation from natural sources, excluding radon, is approximately 1·0 mSv a year.[1] Radon contributes substantially to the total radiation dose but has little or no relevance in a study of leukaemia.[2] The effective dose from medical use of radiation is of the same magnitude (0·8 mSv).[3] Fallout from nuclear bomb testing contributes little to the effect dose (less than 0·01 mSv a year).[4]

In an epidemiological study the aim is to estimate the effect of a given exposure and to control for the effect of other factors. In our study, the effect of